BEAGLE2 / NASA '01
INTERFACE CONTROL DOCUMENT

BEA2.ICD.00002.S.MMS
Issue 1.0

CI CODE: L0000

(For SIGNATORIES see next page)

Matra Marconi Space UK Ltd
Gunnels Wood Road, Stevenage, Hertfordshire, SG1 2AS, England

SIGNATORIES

Astrium	***NASA/JPL***
Prepared By: *……..* *L. WAUGH (MMS)* *Date:*	*Checked by* *.A.VAISNYS.......................………………* *(name)* *Date:*
Checked By: *...……….…R JAYES(MMS)* *Date:*	*Checked by* *A BARBIERI ....………………* *(name)* *Date:*
Approved By: *.....................................………………* *J. CLEMMET(MMS)* *Date:*	*Agreed by* *S. BUTMAN ....………………* *(name)* *Date:*
Authorised By: *.......................…….............................* *J. THATCHER(MMS)* *Date:*	
……………………………………………………………	
DERA *Checked By:* *.....................................………………* *D STANTON (DERA)* *Date:*	
Checked By: *.....................................………………* *M CASSIDY (DERA)* *Date:*	

CONTENTS

Beagle2 / NASA ’01 Interface Control document

1 INTRODUCTION

This document states the performance requirements for the Beagle 2 RF and protocol interface with the NASA Mars Surveyor 2001orbiter hereinafter known as NASA ’01.

Where a conflict arises between this document and the Applicable Documents listed below, this document shall take preference.

Sections 2 & 3 of this document list the Applicable and Reference documents to be read in conjunction with this document.
Section 4 provides an overview of Beagle2 communications including the alternative path via Mars Express Orbiter for completeness.
Sections 5 & 6 detail the requirements of the Physical and Data Link Layers of the Proximity-1 protocol which should be read in conjunction with AD[1] and AD[4].
Section 7 briefly describes Compatibility Testing and should be read in conjunction with AD[5]

Please note that Sections 2 through to 5 are provided for information only. The details for the link implementation are contained in the rest of the document.

It should be noted that Beagle2 is required to operate not only via NASA’01, but also via the lander communications package (MARESS) on board the Mars Express orbiter.

2 APPLICABLE DOCUMENTS

The applicable documents form part of this specification to the extent specified herein. In the event of conflict between this specification and the applicable documents referenced here, this specification shall take precedence and any discrepancy shall be noticed to the prime contractor:

AD[1]	CCSDS Proximity 1.0 Space Link Protocol CCSDS 211.0-R-2	Draft Red book 2
AD[2]	CCSDS Telemetry Channel Coding CCSDS 101.0-B-3	- May 1992
AD[3]	CCSDS Packet Telemetry CCSDS 102.0-B-3	- Nov 1992
AD[4]	Mars Surveyor 2001 Orbiter Relay Data Service Prepared by A Barbieri (JPL)	Version 1.0 7th June/2000
AD[5]	Mars’01 Orbiter – Beagle2 Interoperability Test Plan Prepared by A. Vaisnys (JPL)	Version 0.0 30th May, 2000

Note: In the text, applicable documents are identified as AD[x] as appropriate.

3 REFERENCE DOCUMENTS

RD[1] UHF Transceiver Model C/TT-505 Theory of Operation / User Manual
CE Document # 648855 Revision 1.1 - 9/30/99

RD[2] CCSDS Telecommand Part 1 Channel Service
CCSDS 201.0-B-2 - Nov 1995

RD[3] Telecommand Part 2 Data Routing Service
CCSDS 202.0-B-2 - Nov 1992

RD[4] Telecommand Part 3 Data Management Service
CCSDS 203.0-B-1 - Nov 1986

Note: In the text, applicable documents are identified as RD[x] as appropriate.

4 OVERVIEW

Beagle2 shall be delivered to the proximity of Mars on-board the Mars Express Orbiter from which it will separate to land on the Martian surface. The Beagle 2 Lander shall operate from the surface of Mars, communicating with Earth via either of the two Orbiters – Mars Express or NASA'01. Figure 1 shows communications paths between Earth and Beagle2 (on the surface of Mars) via the two orbiters.
In brief, communications from Earth to each of the Orbiters (Mars Express and NASA'01) is based on the CCSDS Long Link (Deep Space) protocol. Communications between NASA'01 and Beagle2 operating on the surface of Mars are as defined in this document.

The communications protocols and formats used by Beagle2 with the NASA'01 orbiter are shown in Figure 2 for the Forward link and Figure 3 for the Return link.
There are differences in implementation of Proximity-1 by each of the Orbiters and thus the Beagle2 Transceiver must implement two variations of the Proximity-1 Recommendation. The principal difference between the way in which the orbiters operate is that Mars Express treats the data as Source Packet Data whereas NASA'01 treats the data as a serial bitstream and operates as a 'Bent Pipe' Relay.
Which Orbiter is addressing Beagle 2 will be determined by means of the Proximity-1 Virtual Channel Identifier (VCID) used by the Orbiter in its communications with Beagle2.

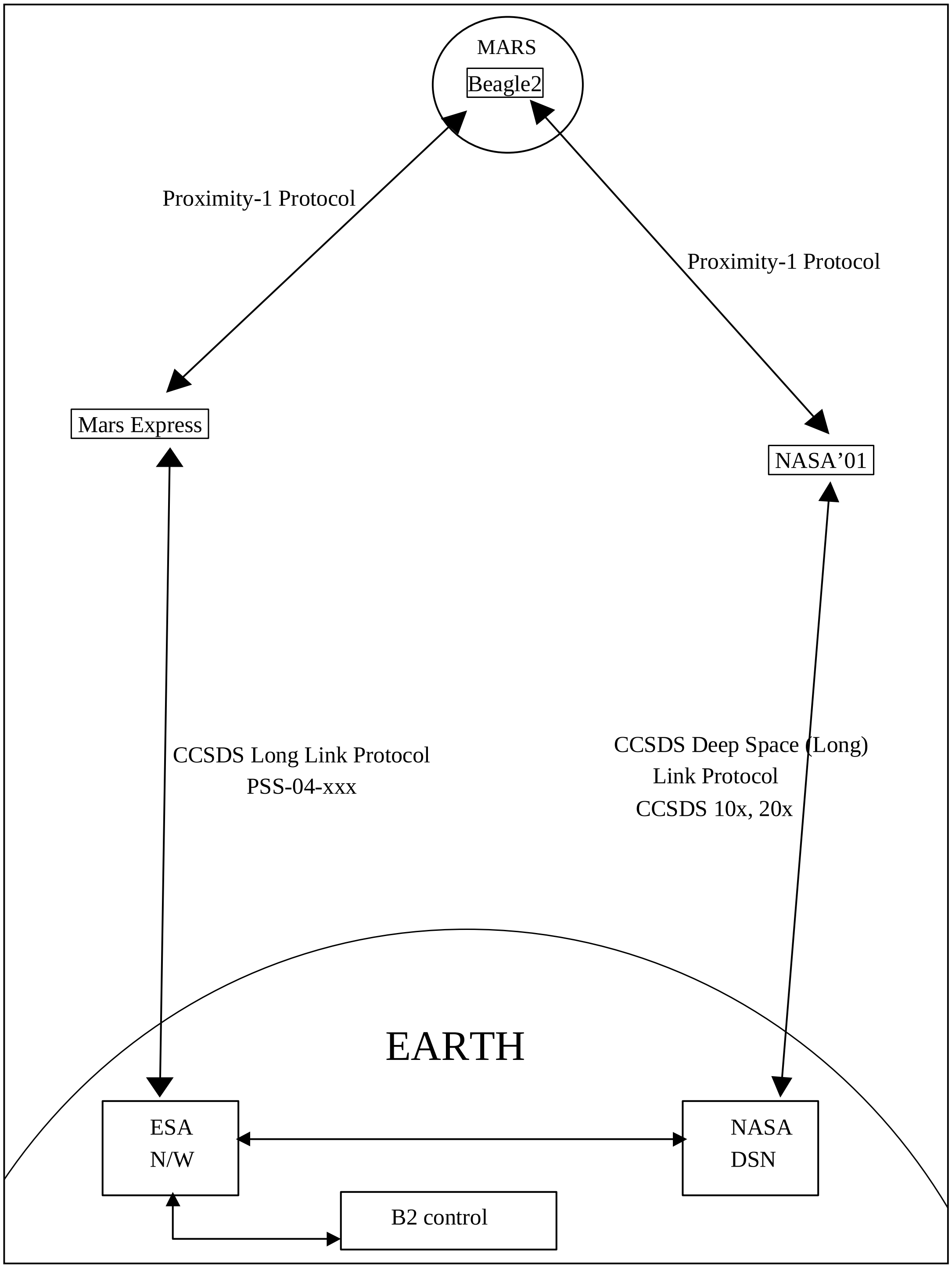

Figure 1 - Beagle 2 Communications overview

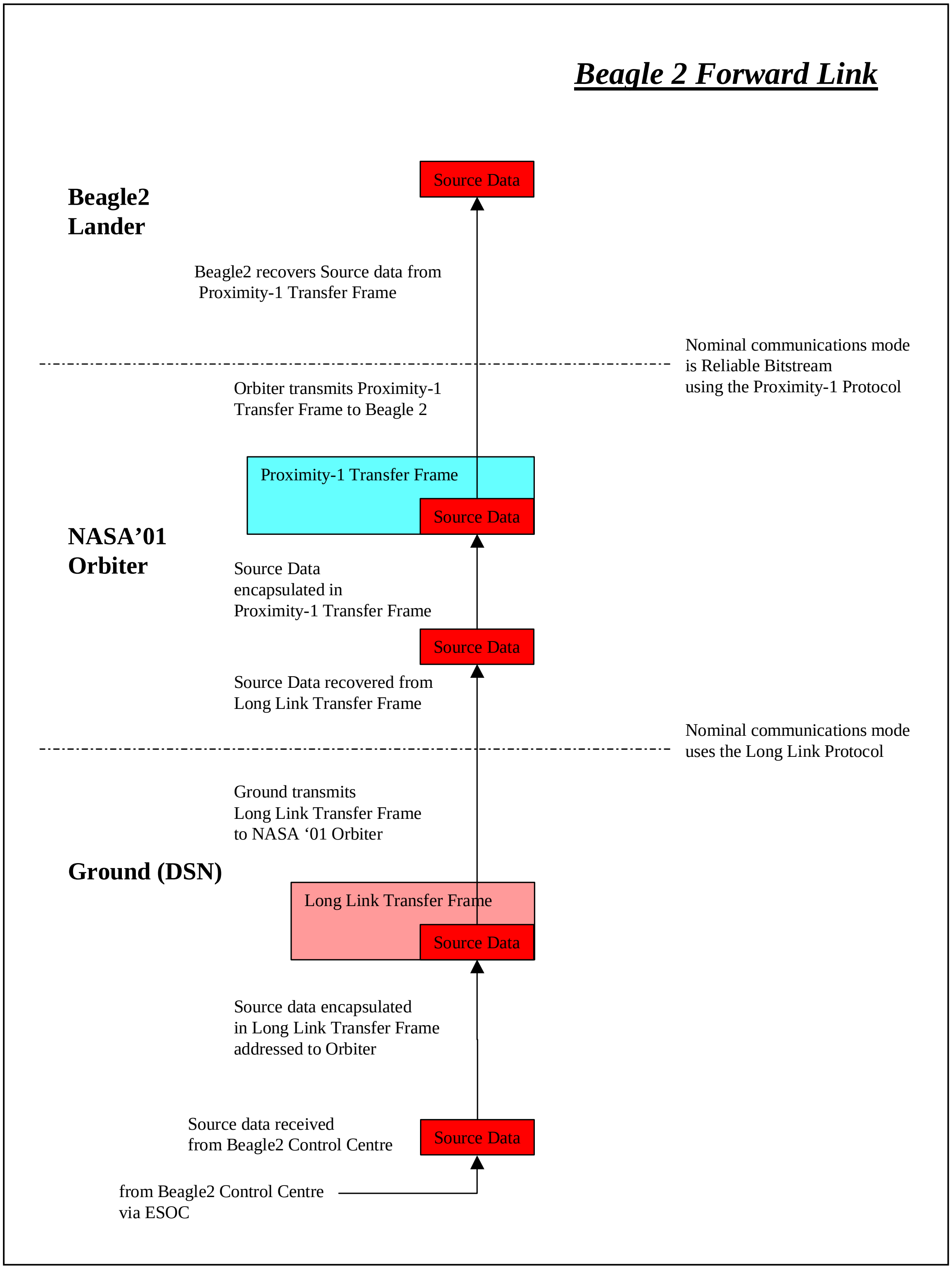

Figure 2 - Forward Link – Protocols and Formats overview

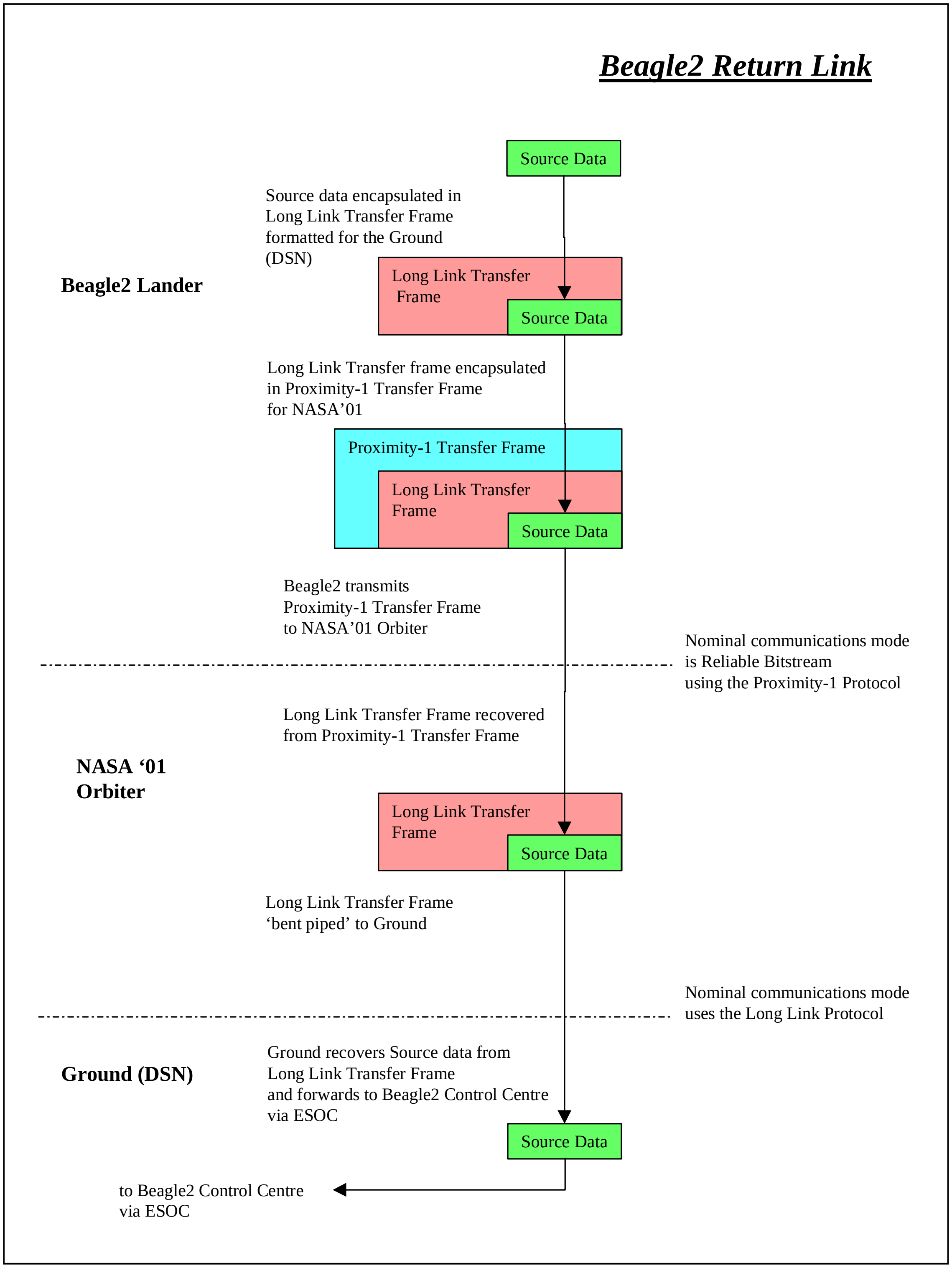

Figure 3 - Return Link – Protocols and Formats overview

5 COMMUNICATIONS TO BEAGLE2 VIA NASA'01

5.1 The Forward Link (Telecommand – Earth to Beagle2)

The following paragraphs describe the sequence that occurs from the time when Source data packets are passed (via NASA'01) from the Beagle2 control centre until they are accepted on-board Beagle2 on the surface of Mars.

a) Source data packets intended for Beagle2 are passed from the Beagle 2 Control Centre to the ESOC control centre using a ground link protocol.

b) The Source data packets are passed to the NASA TMOD & Deep Space Network using the a ground link protocol.

c) The Source data is recovered from the ground link data stream and then encapsulated into the Long Link Transfer frames addressed to NASA'01 and its Relay Data Service Channel i.e. Virtual Channel ID = '06'.

d) The Long Link Transfer Frames containing Source data for Beagle2 are then transmitted to NASA'01 which detects the VCID=06 and places the source data as a bitstream into its Command Relay buffer for Store & Forwarding to BEAGLE2.

e) The NASA'01 Transceiver is commanded and configured to address the Beagle2 Lander during its next communications session i.e. the Beagle2 SCID (038H) is uplinked for use in the Proximity-1 Transfer Frames and the Proximity-1 Link configuration is also uplinked. It is also given a time at which to attempt to Hail Beagle2 to establish a communications session.

f) When the projected time for establishing the communications session is reached the NASA'01 Transceiver Hails the Beagle2 Lander.
Beagle2 Transceiver will be listening for the Hail from NASA'01. NASA'01 will continue its Hailing cycle until the Beagle2 Transceiver detects the Hail and responds, thus establishing the Proximity-1 link and the communications session.

g) The NASA'01 Transceiver then encapsulates the bitstream data (containing the Source data) in Proximity-1 transfer frames, which are transmitted to BEAGLE2.
The nominal mode of operation for the Proximity-1 link is Reliable Bitstream mode which is a Sequence controlled service. This guarantees that all the Transfer Frames delivered within the same session to BEAGLE2 will be in order and without errors, gaps, or duplications.
End-to-end protection for the content of the Source data is provided by including a CRC check within each Source data unit.

h) Beagle2's Transceiver then recovers the bitstream data from the Proximity-1 Transfer Frames and detects the Source packets for forwarding to the Beagle2 data handling system.

5.2 The Return Link (Telemetry – Beagle2 to Earth)

On the return link, source data from BEAGLE2 must be double encapsulated - first in Long Link Protocol Transfer Frames and then in Proximity-1 transfer frames. This is so that when the Proximity-1 Transfer Frames are stripped off by NASA'01, the remaining bitstream which NASA'01 transmits to Earth without processing contains transfer frames (complete with ASM and error detection and correction etc).which are suitable for detection and decoding by the Ground Segment

The following paragraphs describe the sequence that occurs from the time when Source data packets are passed (via NASA'01) from Beagle2 until they are accepted by the Beagle2 control centre.

a) Source data packets are passed from the Beagle2 data handling system to the Transceiver.
b) The Beagle2 Transceiver encapsulates the Source data packets in Long Link Transfer Frames suitable for reception by the NASA Deep Space Network with the Beagle2 SCID.
c) Before they are transmitted, the Beagle2 Transceiver then encapsulates these Long Link Transfer Frames in Proximity-1 Transfer Frames suitable for reception by NASA'01.
d) These doubly encapsulated transfer frames are transmitted from BEAGLE2 to NASA'01 which removes the Proximity-1 transfer frame thus recovering the Long Link Protocol transfer frames which contain the Source data. These Long Link transfer frames are then stored in the Telemetry relay buffer (as a bitstream) for relay to Earth. When they are transmitted to Earth the DSN removes the Long Link transfer frames (containing the Beagle2 SCID) thus recovering the Source data for passing to the BEAGLE2 control centre via ESOC.

5.3 Data Integrity Protection.

The following tables show the methods used to maintain data integrity for each stage of the transmission path between the Beagle2 Control Centre and Beagle2.

Forward link		
Data Source	**Destination**	**Protection used**
Beagle2 control centre	ESOC	(TBA)
ESOC	NASA TMOD	(TBA)
NASA TMOD/DSN	NASA'01	CRC error detection BCH error detection & correction
NASA'01	Beagle2	ARQ Sequence controlled service CRC Error detection

Return link		
Data Source	**Destination**	**Protection used**
Beagle2	NASA'01	ARQ Sequence controlled Service CRC Error detection (TBC) Convolutional Coding
NASA'01	NASA DSN	RS Coding Convolutional coding
NASA TMOD	ESOC	(TBA)
ESOC	Beagle2 Ground Control	(TBA)

5.3.1 End-to-end data integrity protection.

End-to-end protection of Source data is particularly important on the Forward Link where there is a risk that corrupt command data may threaten proper operation of Beagle2. The level of risk could vary from 'relatively insignificant' through to 'mission threatening'.
Generally and in nominal operating modes, each communications link involved in the transmission of Source packet data to Beagle2 utilises data integrity protection which aids an error free delivery of data. Nevertheless, there remain possibilities for data corruption during the end-to-end process.

To cater for situations where end-to-end delivery of data is not successful, retransmission mechanisms at levels higher than the protocol Transmission Layer must be employed. This may even involve manual intervention by the operators of the Lander and does not concern the interface described in this document.

5.4 Session Establishment, Maintenance and Termination

Annex A describes the method and details of Link establishment and Maintenance. Hailing shall always be carried out by the NASA’01 orbiter with BEAGLE2 Transceiver passively monitoring and awaiting the detection of the Orbiter’s carrier and Hailing sequence.

Due to power constraints on-board BEAGLE2 the Transceiver can only be switched on when a communications session is expected to occur. This shall be controlled by BEAGLE2’s Central Electronics Processor which shall be programmed with future expected visibility periods during a current communications session. In the event that BEAGLE2’s on-board software detects that no communications sessions have occurred for an unexpectedly long period of time, BEAGLE2 will go into a ‘best guess’ cycle mode of switching on the Transceiver and listening for overhead orbiters for brief periods during the Martian day (TBC).

5.5 Data & Protocol Entities & Coding methods

Annex A describes the sequence of construction of data entities for the NASA’01 Orbiter. This includes the sequence from source packet data encapsulation on Earth up to the decoding and recovery of source packets on-board BEAGLE2. The NASA’01 Protocol Data Units and any differences in characteristics from the Proximity-1 Recommendation are also described in Annex A as are coding methods employed to improve link performance and maintain data integrity.

5.6 Cautions

When operating in the backup Unreliable bitstream mode, the loss of a data will mean that synchronisation and detection of Source packet boundaries may be lost on-board Beagle2. To help overcome this problem it is intended to create packets which contain ASM bit patterns which shall be interspersed with Source data packets (TBC). If synchronisation is lost the Beagle2 transceiver will search for an ASM bit pattern and when it finds one, will carry out checks to ensure that it has not locked up on data bearing a resemblance to an ASM pattern.

The following sections in this document contain detail of the implementation or the Beagle2 NASA’01 link

6 PHYSICAL LAYER

6.1 Link Description

The Beagle2-NASA ’01 orbiter link will be used for forward transmission of telecommand (TC) signals, and the return transmission of Beagle2 telemetry data, which includes science data. The following definitions are applicable:

Forward link: Transmissions from Earth routed via the NASA ‘01 orbiter to Beagle 2.
Return link: Transmissions from Beagle 2 routed via the NASA ‘01 orbiter to Earth.

The transceiver shall operate in the UHF frequency band, and be compatible with the L2n category of landed elements described in AD1. No ranging function is required.

6.2 Link Characteristics

6.2.1 Orbit Geometry

The Orbit Geometry shall take the form as characterised by the mean orbital parameters in the following table:

End Of Aerobraking - 30-Dec-2001 00:00:00 ET	
Parameter	**Sun-Synchronous Orbit**
Epoch	19-Oct-2003 00:00:00 ET
Semi-major axis	3793.4 km
Eccentricity	0.0
Inclination	92.923°
Argument of Periapsis	0.0°
Longitude of Ascending Node	39.311°
Mean Anomaly	0.0°

The orbiter will nominally be in a circular orbit of approximately 400km altitude. For further details refer to Annex A.

6.2.2 Forward Link – NASA ’01 Orbiter to Beagle2

The forward link shall operate in the UHF frequency band at 437.100 MHz. The link shall conform to the characteristics in the following subsections:

6.2.3 Beagle2 Forward Link

Initial Frequency stability	≤ ± 2.5ppm
Frequency stability	≤ ± 10ppm (including initial frequency setting over the full temperature, voltage range and life time)
Overall stability	≤ ± 10ppm (shall be met within 1 minute following application of power)
Polarisation	RHCP
Maximum doppler range	+/- 10KHz
Maximum doppler rate	+/- 100Hz/s
Data rates	8Kbps for normal operation
Data rate accuracy	+/- 0.1bps
Data rate stability	<± $2x10^{-4}$
Modulation	direct PCM/Bi-phase/PM
Modulation index	60deg
Modulation linearity	<= 3%
Modulation sense	symbol 1 results in advance of carrier phase symbol 0 results in retard of carrier phase

Spectrum symmetry	<=1.0dB
Residual amplitude modulation	< 2%
Coding	no coding

6.2.4 NASA01 Forward Link

The following Parameters characterise the NASA01 Forward Link.

Figure 4 - NASA'01 Forward Link Antenna Pattern (not supplied)

The pattern shown is for the helix alone, before being installed on the orbiter. The radiation pattern after installation is to be determined

Transmitted Power	10 Watts minimum
Circuit Loss	2.2dB (TBC)
Oscillator Stability - Internal Oscillator (TCVCXO).	2ppm over all temperatures & pressures 2 ppm per year
Oscillator Stability - External Oscillator (SSO).	The following Tables contain test results for the Sufficiently Stable Oscillator at the reference frequency of 10.69984375 kHz.

Table 6. Phase Noise vs. offset from carrier[1]

Offset from Carrier	Phase Noise Unit A	Phase Noise Unit B
10 Hz	-130 dBc/Hz	-131 dBc/Hz
100 Hz	-148 dBc/Hz	-145 dBc/Hz
1 kHz	-157 dBc/Hz	-157 dBc/Hz
10 kHz	-165 dBc/Hz	-167 dBc/Hz

Table 7. Allan Deviation[2]

Integration Time	Allan Deviation Unit A	Allan Deviation Unit B
1 s	4.8E-12	4.9E-12
10 s	2.0E-12	1.9E-12
100 s	2.5E-12	2.7E-12
1000 s	4.6E-12	2.1E-11

[1] SSO Tests at Vectron on bread-board SSOs, November 1999
[2] TDL Test Report for SSO Frequency Characteristics, Project Document 722-703, March 2000

The output frequency is stabilized within three minutes after turn on and frequency variations measured are ±0.1 Hz between 20±5°C (expected operational temperature)[11]

6.2.5 Return Link – Beagle2 to NASA'01 Orbiter

The return link shall operate in the UHF frequency band at 401.585625 MHz. The link shall conform to the following characteristics:

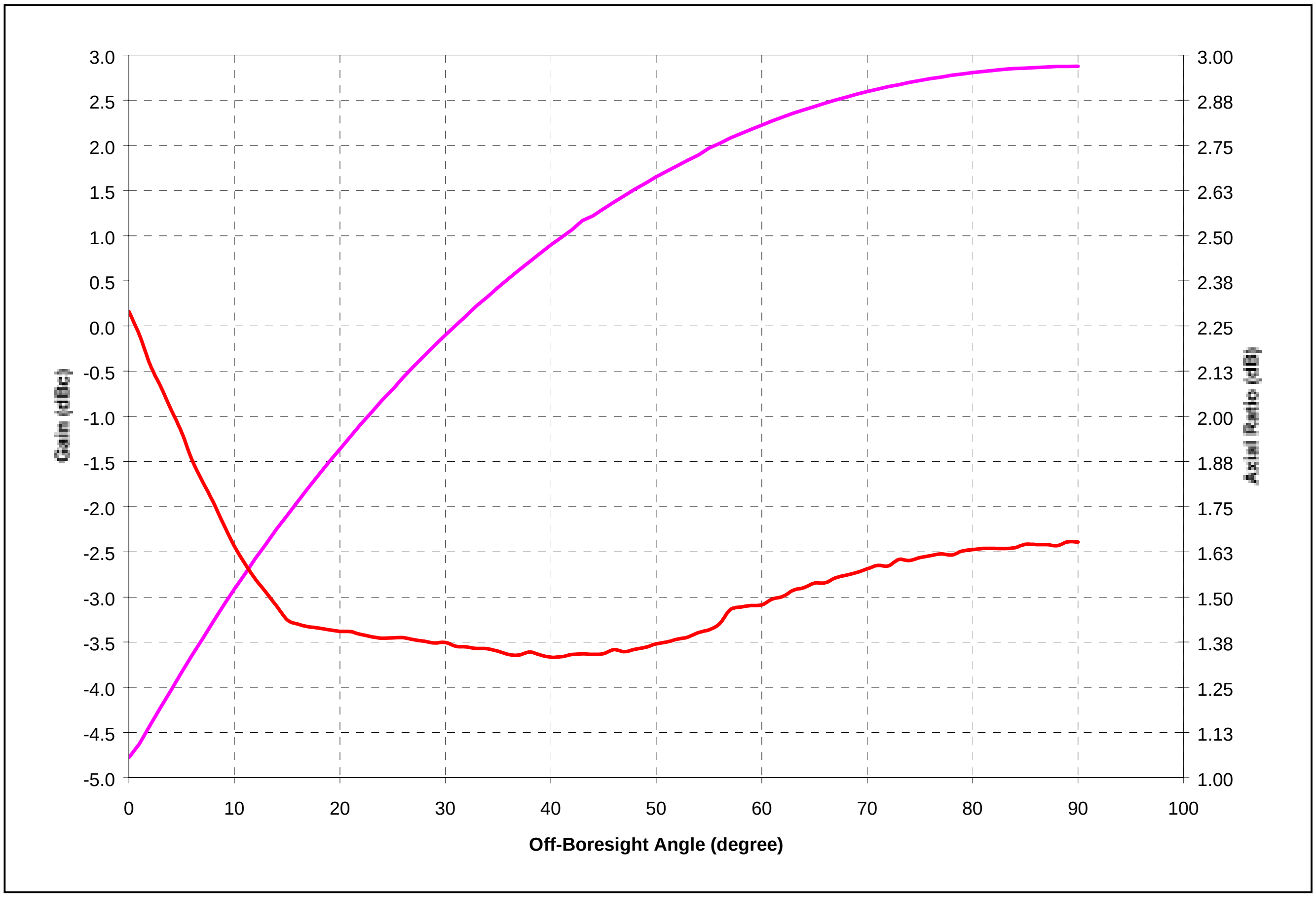

Figure 5 - NASA'01 Return Link Antenna Pattern

6.2.5.1 Beagle2 Return Link

EIRP (Beagle2 on boresight) 37dBm

Polarisation	RHCP
Maximum doppler range	+/- 10KHz
Maximum doppler rate	+/- 100Hz/s
Data rates	8/32/128Kbps
Data rate accuracy	+- 0.1bps
Data rate stability	$< \pm 5x10^{-5}$
Modulation	direct PCM/Bi-phase/PM
Modulation index	60deg
Modulation linearity	<= 3%
Modulation sense	symbol 1 results in advance of carrier phase symbol 0 results in retard of carrier phase
Spectrum symmetry	better than 1.0 dB
Residual amplitude modulation	< 2%
Coding	convolutionally encoded K = 7 rate = ½ (vector G2 not inverted)

6.2.5.2 NASA01 Return Link

The following Parameters characterise the NASA01 Return Link.

Circuit Loss	2.1 dB (TBC)
Threshold Input Power	The following thresholds specify the minimum power required at the input of the UHF receiver to maintain a given data rate with a BER of E-6 as contained in the transceiver specifications. BPSK coded: ▪ 8 kbps -120.5 dBm ▪ 32 kbps -115.5 dBm ▪ 128 kbps -109.5 dBm

6.2.6 NASA Ground station constraints

Due to the 'bent pipe' manner in which NASA'01 operates, source data must be encapsulated in Long Link Protocol Transfer Frames (CCSDS 201.0-B4) so that they can be recognised and decoded by the NASA DSN ground station. Annex C describes the parameter values, format and coding to be used in this process.

6.2.7 Link budgets

The link between Beagle2 and the orbiter has a minimum data volume requirement of 5Mbits per sol in order to provide basic science data returns. This figure is raw science data and does not include any housekeeping data, nor any allowances for coding efficiencies. The mission aims are for a communications link that can provide 10Mbits per sol including housekeeping data.

The following Link Budgets have been calculated as part of a preliminary analysis and are to be revised as better data becomes available.

6.2.7.1 Forward Link Budget

					Comments
Elevation Angle	Deg	40.0	40.0	90.0	
LANDER RX PARAMETERS					
Receiver Circuit Loss	dB	-1.5	-1.5	-1.5	ESA link budget
Antenna Gain	dBi	1.0	1.0	4.0	ESA link budget
Axial Ratio	dB	N/A	N/A	N/A	
LINK PARAMETERS					
Distance	km	581.5	581.5	400.0	Slant range for elevation angle
Link Frequency	MHz	437.1	437.1	437.1	UHF
Space Losses	dB	-140.5	-140.5	-137.3	Calculation
ORBITER TX PARAMETERS					
Transmitter Power					
Pointing angle	deg	26.3	60.3	17.0	Calculation – 17 degrees
Antenna Gain	dBi	2.4	-0.1	2.9	Preliminary pattern – not measured on S/C
Axial Loss Ratio	dB	1.5	1.6	1.4	Preliminary pattern – not measured on S/C
Polarization Losses	dB	N/A	N/A	N/A	
smitter Circuit Loss	dB	-2.1	-2.1	-2.1	Preliminary
TOTAL POWER SUMMARY					
Received Power	dBm	-100.8	-103.3	-94.0	Calculation
8kbps					
Data Bit Rate	kbps	8	8	8	
Data Power Threshold	dBm	-119.1	-119.1	-119.1	NASA'01 Transceiver Specification
Performance Margin	dB	18.3	15.8	25.1	Calculation

6.2.7.2 Return Link Budgets

					COMMENTS
Elevation angle	Deg	40.0	40.0	90.0	
LANDER TX PARAMETERS					
Transmitter Power	dBm	37.0	37.0	37.0	5 Watts
Transmitter Circuit Loss	dB	-0.5	-0.5	-0.5	ESA link budget
Antenna Gain	dBi	1.0	1.0	4.0	ESA link budget
Axial Ratio	dB	N/A	N/A	N/A	
LINK PARAMETERS					
Distance	km	581.5	581.5	400.0	Slant range for elevation angle
Link Frequency	MHz	401.6	401.6	401.6	UHF
Space Losses	dB	-139.8	-139.8	-136.6	Calculation
ORBITER RX PARAMETERS					
Pointing angle	deg	26.3	60.3	17.0	Calculation – 17 degrees
Antenna Gain	dBi	2.4	-0.1	2.9	Preliminary pattern – not measured on S/C
Axial Loss Ratio	dB	1.5	1.6	1.4	Preliminary pattern – not measured on S/C
Polarization Losses	dB	N/A	N/A	N/A	
Receiver Circuit Loss	dB	-2.1	-2.1	-2.1	Preliminary
TOTAL POWER SUMMARY					
Received Power	dBm	-102.1	-104.6	-95.3	Calculation
8kbps					
Data Bit Rate	kbps	8	8	8	
Data Power Threshold	dBm	-120.5	-120.5	-120.5	NASA'01 Transceiver Specification
Performance Margin	dB	18.4	15.9	25.2	Calculation
128 kbps					
Data Bit Rate	kbps	128	128	128	
Data Power Threshold	dBm	-109.5	-109.5	-109.5	NASA'01 Transceiver Specification
Performance Margin	**dB**	**7.4**	**4.9**	**14.2**	Calculation

7 DATA LINK LAYER

7.1 Frame Sublayer

The entities for this sublayer are as described in the PROXIMITY-1 Recommendation (AD[1]) and includes the values and formats listed below for the Reliable Bitstream Mode of operation. The Unreliable Bitstream mode does not require the definitions below for this interface document:

PLTU

ASM	*Transfer Frame*	*CRC*
3 bytes	(see below for length)	4 bytes

Transfer Frame

Header	*Data Field*
5 bytes	(Tr Frame length - 5)

Header

Version Number	*QoS*	*PDU Type ID*	*Data Field Construction ID*	*S/C ID*	*VC ID*	*Port ID*	*Source Destination ID*	*Frame Length*	*Frame Sequence Number*
0,1	2	3	4, 5	6-15	16	17-19	20	21-31	32-39

Figure 6 - Format of the Proximity Link Transfer Unit, of the Transfer Frame and its Header

PLTU components: Attached Sync Marker (ASM) 24-bit (FAF320h)
Version 3 Transfer Frame
32-bit CRC (polynomial $x^{32} + x^{23} + x^{21} + x^{11} + x^{2} + 1$)

Transfer Modes: Reliable Bitstream (nominal mode) with go-back 2 ARQ
Unreliable Bitstream (emergency backup mode)

Transfer Frames type: Version 3
Variable length, asynchronous

Quality of Service/ PDU Type ID
00 = User Data / Reliable Bitstream
11 = PLCW or Set Directive

Data Field Construction ID:
11 = User Defined Data

Spacecraft ID: 38h only (Beagle2) used for BEAGLE2/NASA'01 link

VCID: 0 = Beagle2 link with NASA'01

Port ID: 000

Source Destination ID: 0 = Source - (always used for the return link i.e.Beagle2)

1 = Destination - (always for the forward link i.e. Beagle2)

Transfer Frame length (length dictated by forward/return data rate combination - see table below)

Data Rates		Transfer Frame length	
Forward link	Return Link	Forward link	Return Link
8	8	1024	1024
8	32	238	1024
8	128	42	1024

Frame Sequence No. variable

Transfer Frame Data field:
The data in this field is byte (octet) Aligned with respect to the source data packets

Segment Data Segmentation of data not used at this level

7.2 Medium Access Control (MAC) Sublayer

The Session Establishment Phase is described in Annex 1 which contains the document produced by A Barbieri (JPL) entitled "Mars Surveyor 2001 Orbiter Relay Data Service".

7.2.1 Management Information Base (MIB) Parameters:

Directive PDU's

Directive PDU	*ASM*	*Header*	*Data Field*	*CRC*
	3 bytes	5 bytes	5 bytes	4 bytes

Data Field	*PDU Type*	*PDU Subtype*	*Length*	*Set TX Directive*	*Set RX Directive*
	0,1	2,3	4-7	16 bits	16 bits

Figure 7 - Directive PDU Format

Set Tx/Rx Directive	*Mode*	*Rate*	*Modulation*	*Encoding*	*Frequency*	*Directive Type*
	0,1,2	3,4,5	6,7	8,9	10,11,12='000'	13,14,15

Figure 8 - . Set Transmitter (Tx) and Receiver (Rx) Directives Format

PDU Type	00b
PDU SubType	00b
Length	0100b
<u>Set Tx Directives:</u>	
Tx Mode	001b = Reliable Bitstream (Sequence Controlled) 011b = Unreliable Bitstream
Tx Data Rate	000b = 8kbps 001b = 32 kbps 010b = 128kbps
Tx Modulation	01b non-coherent 10b coherent (Note: PSK coherent shall be the same as PSK non-coherent for the Beagle 2 receiving section)
Tx Coding	01b = Convolutional 10b = bypass coding
<u>Set Rx Directive:</u>	
Rx Mode	001b = Reliable Bitstream (Sequence Controlled) 011b = Unreliable Bitstream
Rx Data Rate	000b = 8kbps 001b = 32 kbps

	010b = 128kbps
Rx Modulation	01b non-coherent 10b coherent (Note: PSK coherent shall be the same as PSK non-coherent for the Beagle 2 receiving section)
Rx Coding	01b = Convolutional 10b = bypass coding
Carrier Only Signal Duration	1 second (TBC) for BEAGLE2 1 second for NASA'01
Idle Pattern Duration Idle Pattern Duration	4096 bits for BEAGLE2 4096 bits for NASA'014096 bits (TBC) for BEAGLE2
Called Spacecraft ID	038h = BEAGLE2
ASM bit Error Tolerance	2 (TBC)0
Hail Frame Interval TBD seconds BEAGLE2	5.53 seconds NASA'01
Transmit State Durations	Mission Dependent (TBD)For Ground Tests: no limit (NASA'01 & Beagle2) On-station Operations: 15 minutes limit (NASA'01 & Beagle2)
Frequency Bit Rate Change	No frequency Bit Rate change shall take place during the Data Services phase of a communications session
MAC Initialisation Procedure	Continuance of Transfer Frame sequence over several communications sessions is not required. Thus the programming of operational parameters V(S, VV(S), NN(R) and V(R) is not required during MAC initialisation (TBC)
Hail Procedure	The Orbiter shall alwayswill be the Hailer and the Lander shall will be the Responder (see Annex A for a description and details of the hailing sequence.

8 LONG LINK TRANSFER PARAMETERS DEFINITION (RETURN LINK ONLY)

(See Annex C - Long Link Transfer Parameters definition (Return Link only)

9 COMPATIBILITY TESTING

The Compatibility and Interoperability tests to be carried out between BEAGLE2 and NASA'01 are outlined in Annex B.

9.1 Schedule dates for compatibility and interoperability testing

Details of the proposed opportunities and methods for Compatibility and Interoperability testing are contained in Annex B. A brief summary is given below:

EIM level – hard-line RF test
Full RF test
NASA'01 Spacecraft BEAGLE2 RF test

These tests and dates need to be discussed, detailed and firmed up.

Annex A – Mars Surveyor 2001 Orbiter Relay Data Service description

Annex B – Compatibility and Interoperability Testing between NASA’01 & Beagle2

Annex C – Long Link Protocol format (Return Link only)

(Beagle 2 Interface to NASA DSN)

10 LONG LINK PROTOCOL FORMAT (RETURN LINK ONLY)

In its communications with Earth via the MSP'01 Orbiter (hereafter referred to as NASA'01) Beagle 2 must double encapsulate its Source Data Packets. It will first encapsulate them in Long Link Protocol Transfer Frames which will then be encapsulated in Proximity-1 Transfer frames for transmission to the NASA'01 Orbiter.
When the Proximity-1 Transfer Frames are received by the NASA'01 Transceiver, the Proximity-1 headers will be removed and the Long Link Transfer Frames which remain will then be transmitted to the NASA DSN. Thus the Long Link Transfer Frames must conform to a format acceptable by the NASA DSN.

The form and parameters of the Long Link TM frames (see CCSDS 102.0-B-4 Recommendation. Fig 5-1) to be generated by the transceiver are:

Frame length	10080 bits (incl RS)
Reed-Solomon	required
Virtual Fill	3 bytes per codeblock (3x8x5=120bits)
Interleaf depth	5
Convolutional coding	not required
Transfer Frame version number	00b
Spacecraft ID	038h
VC ID	01h (TBC)
OCF Flag	0b
Master Channel Frame Count	Monotonically increasing per frame
Virtual Channel Frame count	Monotonically increasing per VC
TF Secondary Header Flag	0b
Sync Flag	0b
Packet Order Flag	0b
Segment Length ID	11b
First Header Pointer	(see AD[3] CCSDS 102.0-B-4 Recommendation Section 5.1.5.5)
Secondary Header	No secondary header
Data Field	Max length TBD
Operational Control Field	Not required
Frame error Control Field	Not required in presence of R-S coding

The Long Link TM frames with the ASM and Reed Solomon shall be contiguously placed into Proximity-1 frames using the maximum length Prox-1 frame, unless no frames are available, in which case a truncated Proximity-1 frame shall be used. Idle frame generation is unnecessary. If an incomplete TM frame is held in the transceiver and there is no data available from the Beagle 2 Central Electronics Processor, an idle packet shall be generated to fill the TM frame (see AD[3]CCSDS 102.0-B-4 Recommendation Section 3).